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PRINCIPAL INVESTIGATOR: Yu-Dong Yao, Ph.D.

CONTRACTING ORGANIZATION: Stevens Institute of Technology
Hoboken, NJ 07030-5591

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Yu-Dong Yao, Ph.D.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Stevens Institute of Technology
Hoboken, NJ 07030-5591

E-Mail: yyao@stevens.edu

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Providing mammographic services to women in underserved areas via telemammography is very important. With remote computer-aided breast cancer detection and diagnosis, it has the advantage of higher penetration of women for cancer screening. This training program relates to research to develop a new telemammography scheme which is directed at the development, optimization, and evaluation of a new class of computer-assisted diagnostic system for telemammography applications. Through this training program, the trainees learn the process of breast cancer diagnosis and the role of mammography, understand the role of wireless communications in telemammographic services. Specific projects in this year's program include implementing cross platform audio and video streaming for telediagnosis in a telemammography network.

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- An Undergraduate Summer Training Program

1. Introduction

Providing mammographic services to women in underserved areas via telemammography is very important [1-3]. With remote computer-aided breast cancer detection and diagnosis, it has the advantage of higher penetration of women for cancer screening. This training program relates to research to develop a new telemammography scheme which is directed at the development, optimization, and evaluation of a new class of computer-assisted diagnostic system for telemammography applications. In the new telemammography scheme, we use Internet and wireless transmission medium to provide mammography to women in regions where physicians who specialize in diagnosing breast cancer are scarce.

Through this training program, the trainees learn the process of breast cancer diagnosis and the role of mammography; establish understanding of mammography; learn the basic principle of medical image processing; understand the role of wireless communications in telemammographic services; understand the architectures of wireless communications systems; understand the performance impact of wireless systems on telemammography [4]; and program and design elements for a wireless system/test bed.

The following table (Table 1) summarizes this year's training team and related projects.

Table 1 Team 2004 and Projects

Student	Mentor	Project
Hesham Wahba	Dr. Hong Man	Implementation of cross platform audio and video streaming as applied to telediagnosis
Parth Thakker		
Kwesi Kerr	Dr. Uf Tureli	Development of handheld applications as applied to wireless telemammography networks
Patrick Deluca		
Owen Bossola	Dr. Wei Qian,	Interactive performance evaluation and detection performance evaluation of wireless telemammography networks
Kevin Lynch	Dr. Yu-Dong Yao	
Rob Hudson	Dr. Yu-Dong Yao	Wireless Transceiver development as applied to wireless telemammography networks
Humza Shahid		
Khajak Mouradian	Dr. Yu-Dong Yao	Improvement of tri-band transceiver for wireless telemammography networks

2. Report Body

2.1 The Training Program

2.1.1 Training Program Overview

In the summer of 2004, we ran our second-year training program under this award/funding support. The program/activities are designed heavily based on our first program in the summer of 2003. Nine undergraduate students participate in the training program. There are 4 mentors (Profs. H. Man, U. Tureli, W. Qian, and Y. D. Yao). Additionally, there are two graduate students (Jin Yu and Nishant Kumar) interacted with and advised the undergraduate trainees. The undergraduates participated in six projects (see subsection 2.2.2).

2.1.2 Training Elements

This 12-week training program is organized and scheduled into 12 units. There are learning elements (Java programming and socket programming) and laboratory assignments (electronic components selection and testing) for each unit. There are presentations and seminars by mentors. Another important element is the weekly all-hands meetings.

2.1.3 Weekly Meetings

There are weekly all-hands meetings for trainees to report work progress and plans for the following week. Appendix shows several photos taken at the weekly meetings. Mentors, graduate students and undergraduate trainees have extensive interactions through the weekly meetings. Students also gain experiences in presentations and professional communication. Students set up personal research web page and post their weekly reports and research documents.

2.1.4 Mentor Involvement

Faculty members (Dr. Yu-Dong Yao, Dr. Hong Man, Dr. Uf Tureli, and Dr. Wei Qian) interacted with students frequently. A number of graduate students worked with the undergraduates in a team and contributed significantly to the training program. Faculty mentors and undergraduate trainees attend weekly all-hands meetings. Such a group setting serves an important mentoring process. Additionally, faculty mentors visit the trainees in the research laboratory at least once a week, thus ensuring individual mentorship (mentor-trainee) once a week.

2.2 Study and Research Areas

2.2.1 Test Bed and Telemammography Network Architecture

A telehealth network architecture was first developed. As shown in Figure 1, there are four service zones in a wireless telemammography network. Zone 1 represents a breast cancer diagnosis center which is located in a metropolitan center and serves as a central hub performing functions such as patient on-site screening, remote telescreening, telediagnosis, teleconsultation, and tele-education. Storage and processing of patients' records are also the responsibility of Zone 1. High-speed Internet access is available to connect with other Zone 1 centers and remote clinics. Remote breast cancer clinics located in suburban areas are considered to be in Zone 2 where high-speed Internet access is available. Connecting to Zone 1 through Internet, telescreening can be conducted for patients. For remote areas, we may consider transportable breast cancer clinics which connect to breast cancer diagnosis center (Zone 1) through wireless Internet to perform telescreening. This is classified as Zone 3. One of the tasks in the research is to develop schemes to transport multimedia applications (such as remote telescreening, telediagnosis, teleconsultation, and tele-education) through wireless communications channels. Zone 4 is the same as Zone 3 with the exception that terrestrial wireless access is not available. We thus need to reply on satellite systems to act as the transmission media in Zone 4. It is seen that a wireless transmission entity is in the center of the network. The summer training program focuses on the development of software packages to provide teleconferencing capability between the remote site and the central office and the development of radio frequency transceiver.
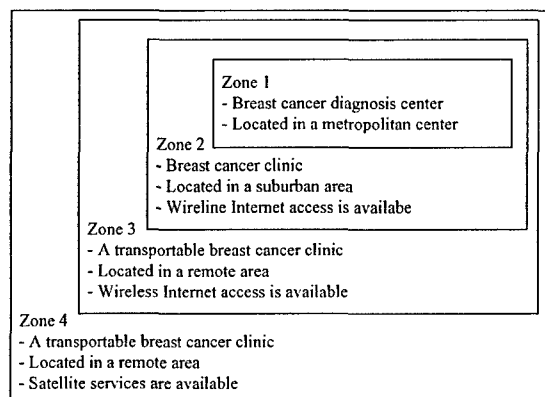


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Zone 1
- Breast cancer diagnosis center
- Located in a metropolitan center

Zone 2
- Breast cancer clinic
- Located in a suburban area
- Wireline Internet access is availabe

Zone 3
- A transportable breast cancer clinic
- Located in a remote area
- Wireless Internet access is available

Zone 4
- A transportable breast cancer clinic
- Located in a remote area
- Satellite services are available
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Figure 1

2.2.2 Projects

The following lists five projects conducted in the summer program,

(1) Development and implementation of cross platform audio and video streaming for telediagnosis in a telemammography network. Two students participated in this project. Prof. Han is the supervisor. In this project, trainees gain experiences in network architecture, multimedia networking, audio/video streaming, and socket programming.

(2) Development of handheld applications as applied to wireless telemammography networks. Two students are in this project. Prof. Tureli supervised this project. In this project, trainees gain experiences in wireless communications, wireless test bed, software programming, and user interface design for handheld devices.

(3) Interactive performance evaluation and detection performance evaluation of wireless telemammography networks. Two students worked with Prof. Qian and Prof. Yao in this project. In this project, students gain experiences in analytical performance evaluation and Java programming.

(4) Application of microprocessors and wireless transceiver development. Two students worked on this project with Prof. Yao. An integrated microprocessor and transceiver platform was developed and tested, with applications in a wide range of wireless communication networks.

(5) Development of a tri-band RF front end (900 MHz, 2.4 GHz, and 5.7 GHz) for a wireless telemammography test bed. One trainee worked with Prof. Yao on this project. Performance improvement has been made in the test bed platform in terms of flexibility and adaptive features.

2.2.3 Tri-Band RF Front End

One of the important accomplishments of the Summer 2004 training program is the successful development of an improved RF transmission front end with three operation bands, 900 MHz, 2.4 GHz, and 5.7 GHz. Figure 2 shows a block diagram of the tri-band RF front end.
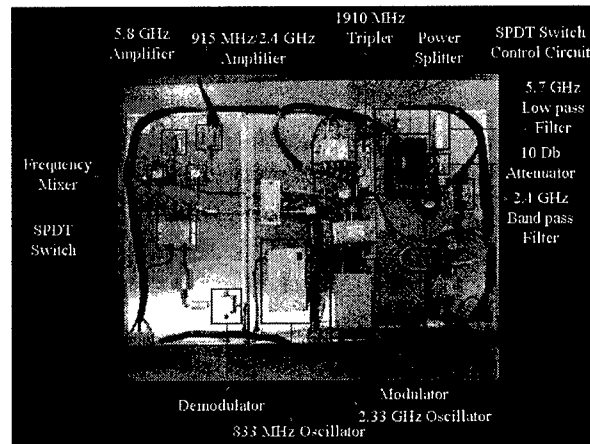

Figure 2 Completed STB board.

2.2.4 Cross Platform Audio and Video Steaming

The goal of this research effort is to create a video conferencing application for telediagnosis with cross-platform support and with features that would make it useful for many to many situations as well as one to many or one to one situations. The application was written in C++ and uses the Simple Directmedia Layer library, the video 4 Linux API, and DirectVideo and DirectSound provided by Microsoft's DirectX API. The application can successfully stream video from one peer to another over an internet connection. A window opens on the computers when a video conferencing connection is made and each peer will see video from connected peers. The audio portion of the project was also implemented. The prototype/software package can be broken down into functional sections by its different threads (sub-processes created by a process). Figure 3 shows the different threads and their relationships.
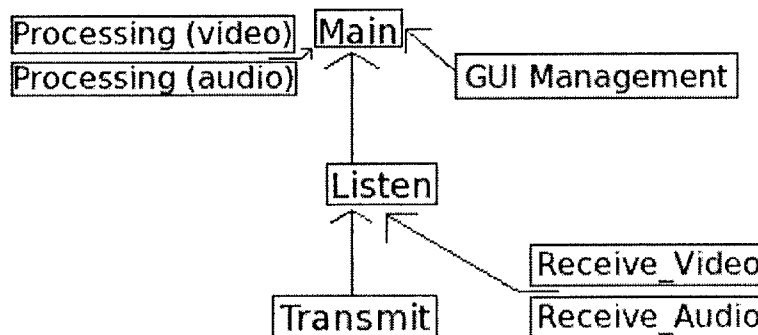

Figure 3 Threads and relationships in the software package

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3. Key Research Accomplishments

- A telehealth and telediagnosis network architecture (Figure 1) was defined, with applications to telemammography
- A software package providing cross platform audio and video streaming as applied to telediagnosis for applications in a telemammography network
- A tri-band (900 MHz, 2.4 GHz, and 5.7 GHz) RF front end was developed and improved in terms of flexibility and adaptive features

4. Reportable Outcomes

- Developed a cross platform audio and video streaming software package, which is intended for communications between remote sites and a central office in a telemammography network

- Developed a tri-band RF front end, which is a key component of a wireless test bed for the telemammography network

- Submitted a funding proposal for the BRCP Idea Award program, Multimedia Detection and Diagnosis of Breast Cancer via Internet and Wireless Networks, to support a comprehensive test bed development

5. Conclusions

This training program has given undergraduate students good opportunities to understand the importance of mammography and telemammography. It shows engineering students (electrical and computer engineering) the role of engineering and technology in health care and medical services. The training program also enables the undergraduate students interact with faculty and graduate students in learning and research. The Summer 2004 program also results in one developed software package and one hardware RF transceiver, both can be used in the telemammography network test bed.

6. References

[1] J. M. Fitzmaurice, "Telehealth research and evaluation: implications for decision makers," Proceedings of Pacific Medical Technology Symposium, pp.344-352, Aug. 1998.

[2] J. Togno and D. Topps, "Policy on using information technology to improve rural health care," Proceedings of International Workshop on Advanced Learning Technologies, pp.260-261, Dec. 2000.

[3] M. P. Gagnon, L. Lamothe, J. P. Fortin, et al., "The impact of organizational characteristics on telehealth adoption by hospitals," Proceedings of the 37th Annual Hawaii International Conference on System Sciences, pp.142-151, Jan. 2004.

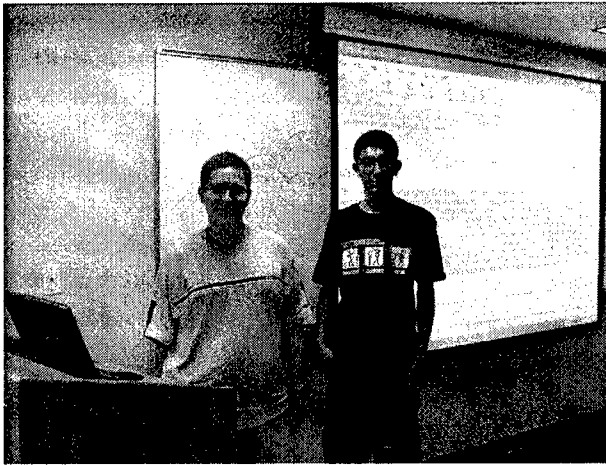## 7. Appendix: Student Activity Photos

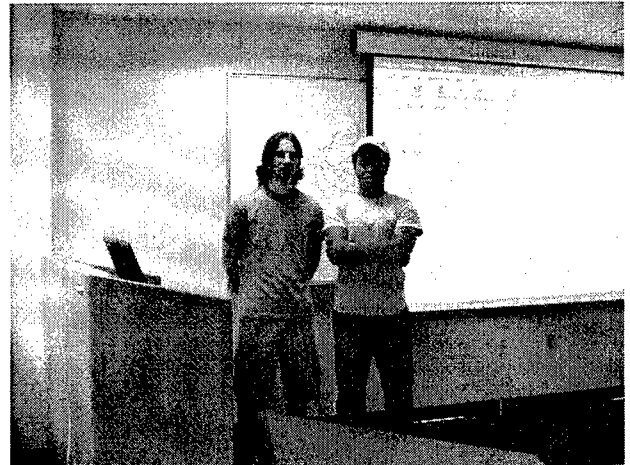Figure 4 Student presentations at a weekly all-hands meeting.

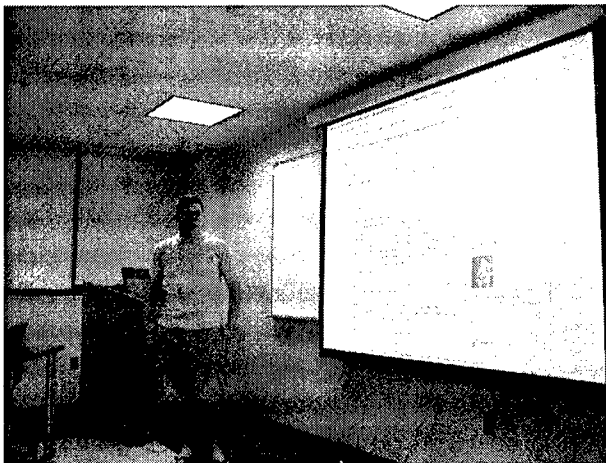Figure 5 Student presentations at a weekly all-hands meeting.

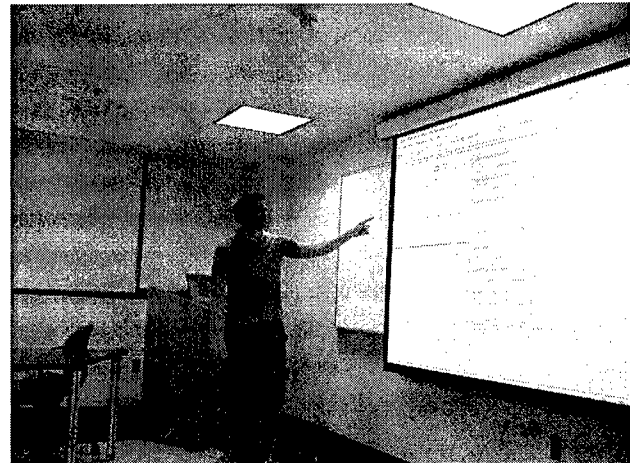Figure 6 Student presentations at a weekly all-hands meeting.

Figure 7 Student presentations at a weekly all-hands meeting.